PG&E Vehicle Grid Integration R&D Update

December 2017

Together, Building a Better California

R&D Pilot Projects

2017

ChargeForward Pilot — Completed

PG&E partnership with BMW to demonstrate feasibility of managed charging

- Phase 1 final report published[1]
- Total Charge Management (i.e. Phase 2) is ramped up and will run until March 2019
  - BMW received CEC EPIC funding, PG&E provides technical assistance

Vehicle to Home — In Process

2018 and Beyond

Load Management for Ridesharing EVs — Proposed

- Understand unique load characteristics of ridesharing with EVs and DCFCs
- Assess ability to actively manage grid demand from charging

SB 350 Priority Review Projects — Decision Pending

PG&E proposed 5 short-term (1-year) pilots/projects in Jan application

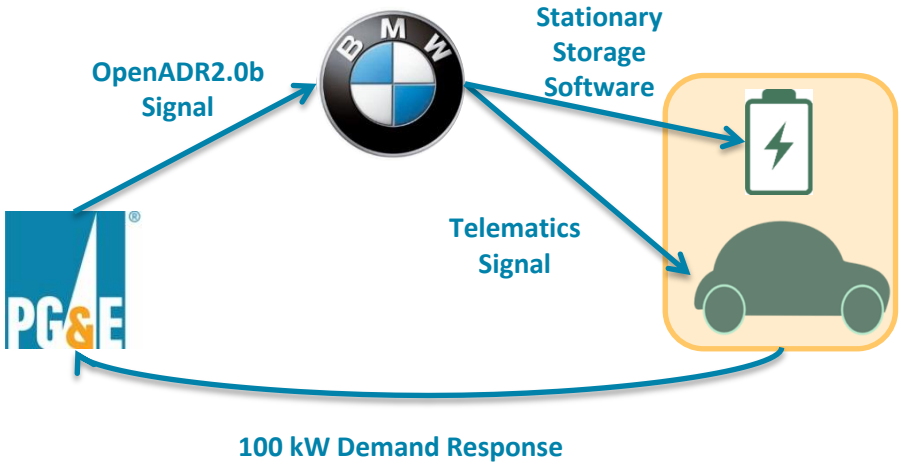
- CPUC 11/22 Proposed Decision would approve 4 of 5 projects

[1]http://www.pgecurrents.com/2017/06/08/pge-bmw-pilot-successfully-demonstrates-electric-vehicles-as-an-effective-grid-resource/

Completed

PG&E Demand Response Pilot: BMW ChargeForward

PG&E is partnering with BMW to explore the potential for using EV charging as a reliable grid resource without impacting customer mobility



ChargeForward Pilot (Phase 1)

Two-year “smart charging” pilot (Jan 2015 - Dec 2016) with BMW providing PG&E with 100kW of grid services (capacity) for 1-hour DR events. Met pilot goals by demonstrating:

- Automaker as a grid-services aggregator model
- Technical feasibility of EV charging curtailment and second-life EV batteries for grid services
- Customer willingness to participate in EV load management programs

PG&E-BMW ChargeForward Lessons Learned

EV Resource

- BMW met the event performance target (>90kW) for 90% of the 209 events
- On average 7 out of 92 customers (7.6%) participated per event
- Average vehicle contribution per event was 4.4 kW
- Average signal Latency of 2.3 minutes & average vehicle response time of 3 minutes (BMW believes they can get latency down to 10-30sec range)

Customer Participation & Motivation

- Significant demand for the pilot – over 500 customers indicating interest in 100 available spots
- 92% (a 4 and 5 rating on a five point scale) of customers were satisfied in the project and 86% indicated they would recommend the program to a family or friend
- Customers interested in participating in managed charging both for monetary incentive and to increase renewable fueling

In Process

ChargeForward Next Steps

Total Charge Management Pilot (Phase 2)

BMW received CEC EPIC grant (through March 2019) to pursue expanded tests:

- Longer curtailment events
- Optimizing nighttime charging
- Increasing charging in response to excess solar
- Shifting charging across grid locations
- New messaging to engage customers

PG&E providing technical assistance

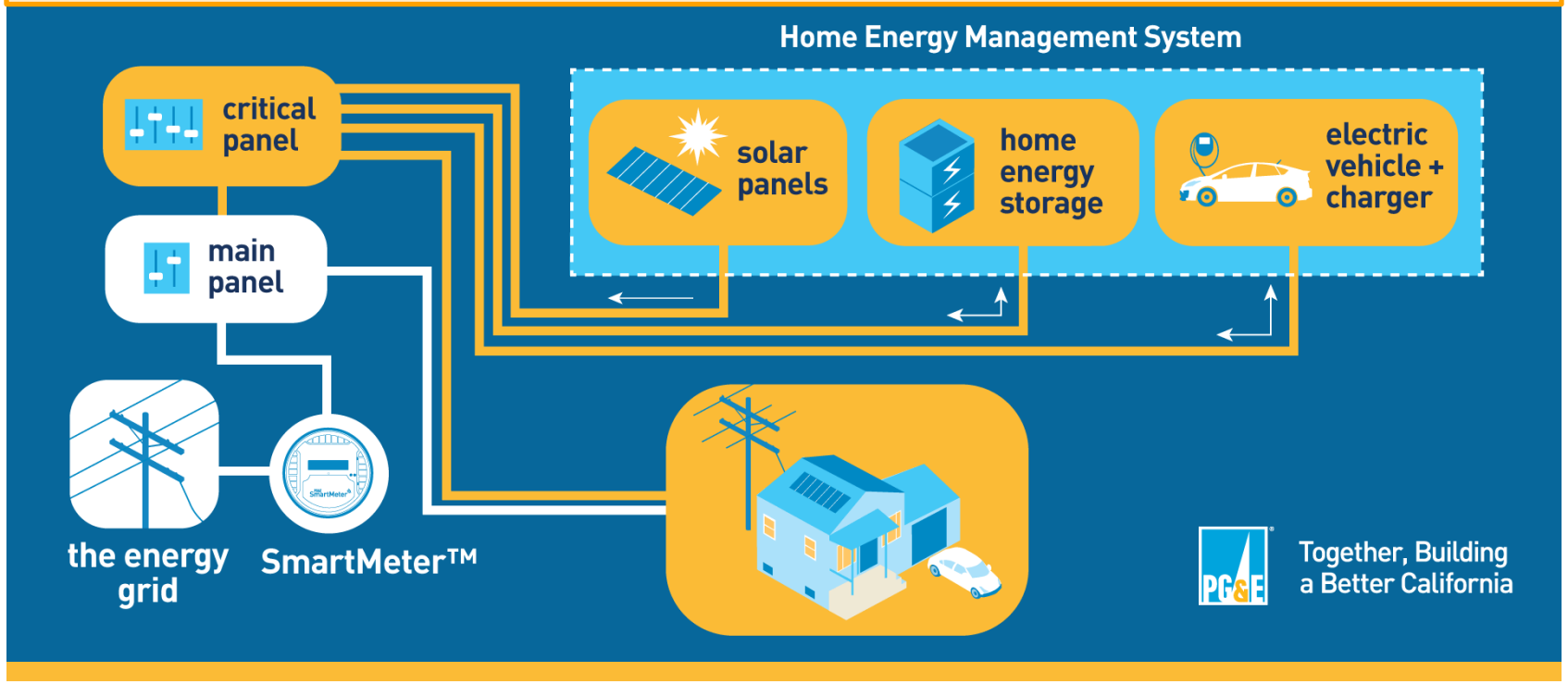
In Process

EPIC 2: Vehicle to Home Demonstration

Project Objectives

Demonstrate V2H technology to:

- Investigate if bi-directional power flow EV, in combination with residential sited customer storage and solar, can power a customer's home during a DR event or outage
- Assess the customer benefits of V2H, and thus the potential ratepayer benefits



EPIC 3: Electric Load Management for Ridesharing Electrification Pilot Project

Proposed

The Opportunity

- 100+ Chevy Bolts already being used to give rides, SF is ground zero for use of EVs in rideshare / sharing economy driving
- 1 Rideshare EV = 4 normal residential EVs (in terms of mileage)
- Rideshare EVs charge during the day at DCFC (50kW), Residential EVs charge at home L1 (1.8kW) or L2 (3-20kW)
- Coalition of stakeholders interested in promoting and accelerating EV adoption broadly and specifically for the Rideshare segment

Project Objectives

Support EV adoption in Rideshare by:

1. Assessing ability to minimize grid impacts and reduce fueling cost for benefit of both drivers and utility
   - Model what optimal charging would look like and identify opportunities to improve the Rideshare EV charging profile
   - Test ability to change driver charging behavior with messaging and/or incentives
2. Exploring ability to expand DCFC availability
3. Measuring benefits of rideshare electrification for disadvantages communities

SB350: Priority Review Projects

Decision Pending

Project 1: MD/HD Fleet Customer Demonstration

Goal: demonstrate lower total cost of ownership for customer fleet electrification with utility assistance

Description: Deploy make-ready infrastructure and charging management tools to minimize operating costs

Project 2: Idle Reduction Customer Demonstration

Goal: demonstrate economic viability for technology deployment with utility assistance

Description: Deploy make-ready infrastructure and charging management tools to minimize operating costs

Project 3: School Bus Over-generation pilot

Goal: test rate and incentive structures to target EV charging during periods of over-generation

Description: Leverage unique duty cycle of school bus fleet to charge vehicle mid-day for grid benefit

Project 4: Home Charger Information Resource

Goal: simplify home charger purchase and installation process to lower barriers for new EV owners

Description: Develop online tool for homeowners to understand home charging needs and identify electrical contractors for charger installation

Project 5: Open RFP

Goal: Identify additional projects for utility investment and encourage innovation and competition among 3rd parties

Description: Open, external request for proposals for 3rd party projects to fund

Thank You

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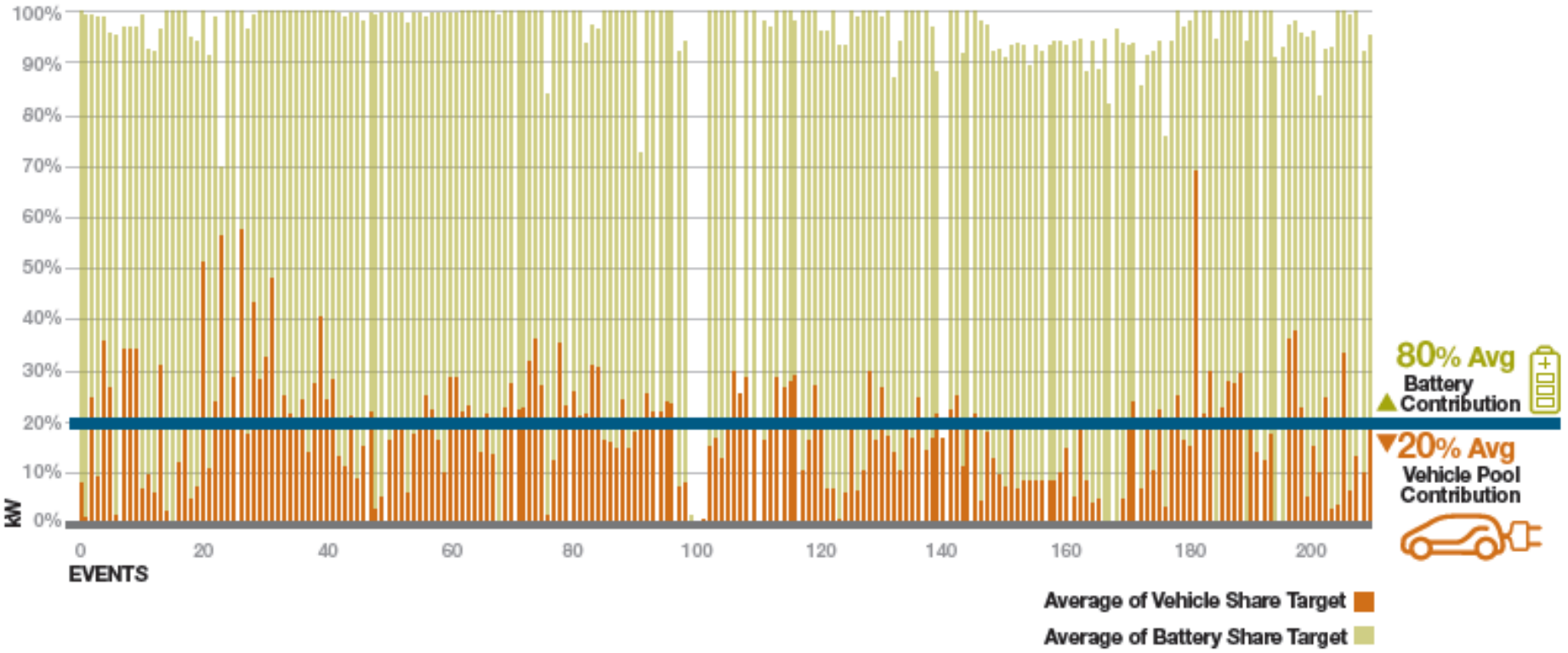
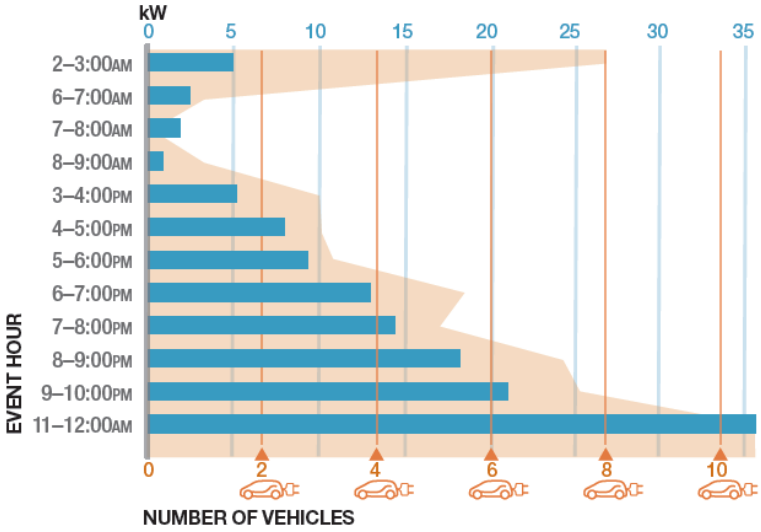
PG&E-BMW ChargeForward Pilot
The vehicle pool contributed 20% of the target kW

EV Resource - Performance

- BMW met the event target (>90kW) for 90% of the 209 events

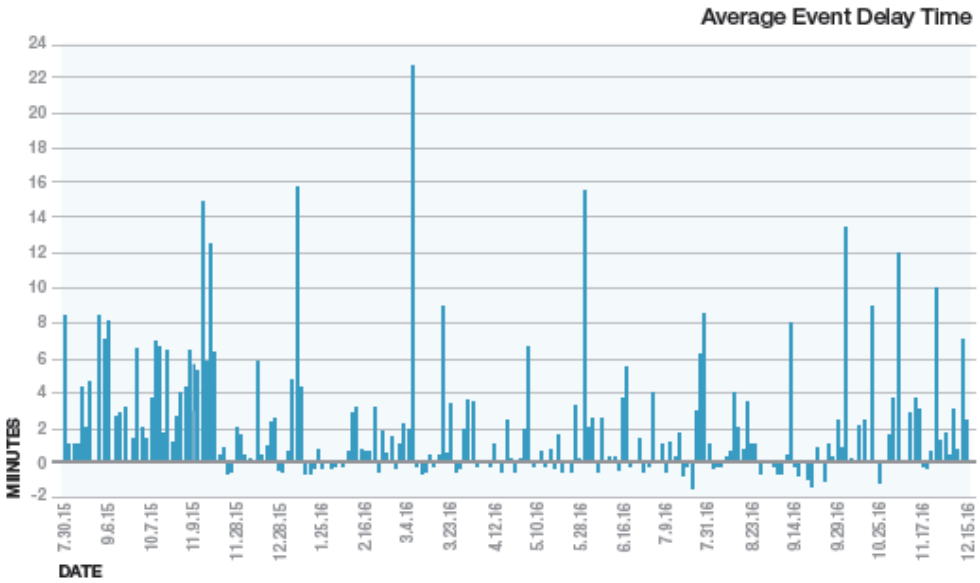


PG&E-BMW ChargeForward Pilot
Availability & response key resource



EV Resource – Availability

- On average 7 out of 92 customers (7.6%) participated per event
- Average vehicle contribution per event was 4.4 kW

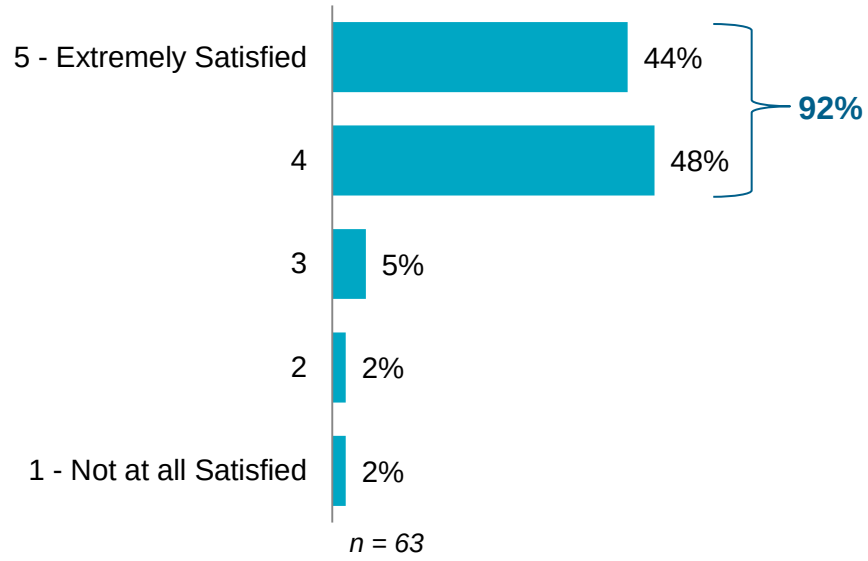


EV Resource - Response

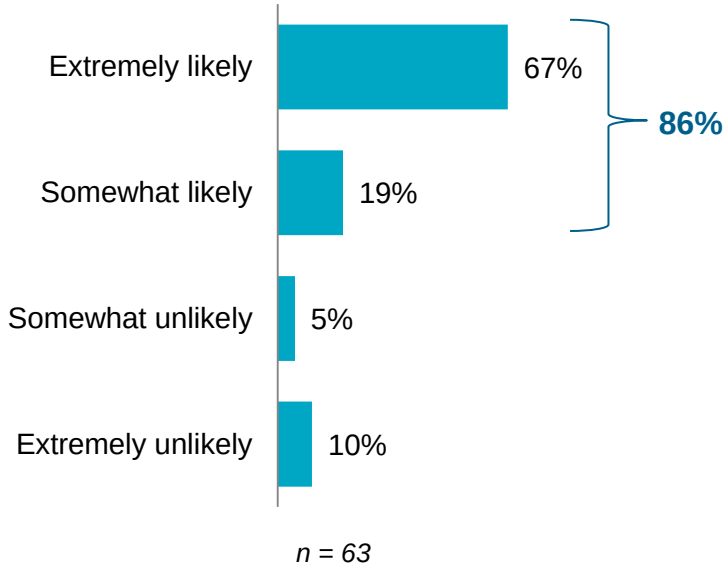
- Average signal Latency of 2.3 minutes *(BMW believes they can get latency down to 10-30sec range)*
- Average vehicle response time of 3 minutes

PG&E-BMW ChargeForward Pilot
Customers were engaged & had positive experience

Overall, how satisfied are you with the program?



How likely are you to recommend the program to your family and friends who qualify?



PG&E-BMW ChargeForward Pilot
Customers motivated by green and monetary benefits

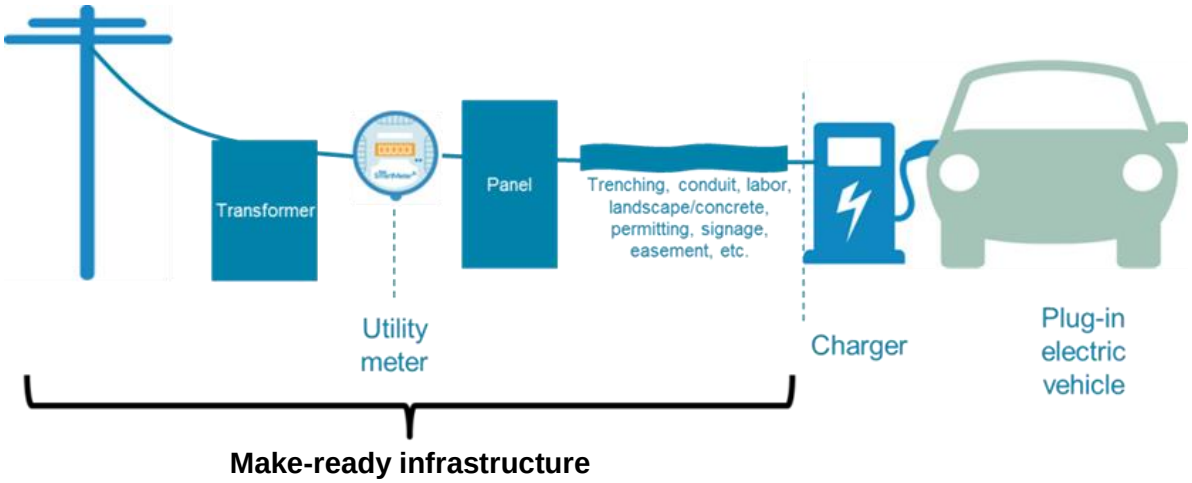
BMW i ChargeForward
PG&E's Customer Voice Panel

Likelihood to participate at home and work if EV is charged with renewable energy

Likelihood to participate at home and work (between 9 AM–4 PM) in order to charge EV with solar energy

Likelihood to participate at home and work if offered additional monetary incentive

Investing in EV infrastructure



EV Charge Network

APPROVED

- 7,500 Level 2 chargers (10-20 chargers per site)
- $130 million; 3 years
- Targeting Workplaces, multi-unit dwellings
- 20% goal, additional incentives in Disadvantaged Communities
- Turnkey installation from utility covers most costs

FleetReady

PROPOSED

- Make-ready infrastructure for non-light-duty fleets (e.g. delivery vans, transit buses, forklifts, truck refrigeration)
- $211 million; 5 years
- Program sized to meet forecasted adoption
- Additional incentives for disadvantaged communities, school and transit buses

Fast Charge

PROPOSED

- 50+ plazas for DC Fast Charging; utility provides make-ready infrastructure
- $22 million; 5 years
- Corridor and urban sites
- Plan for variety of power requirements (50 – 350 kW)
- Additional incentives for disadvantaged communities